

# **LITTLE COLORADO RIVER NATIVE FISH MONITORING 1996 ANNUAL REPORT**

Mark J. Brouder and Timothy L. Hoffnagle  
Research Branch  
Arizona Game and Fish Department  
2221 West Greenway Road  
Phoenix, Arizona 85023



Submitted to:

Bureau of Reclamation  
Upper Colorado Region  
Glen Canyon Environmental Studies  
Flagstaff, Arizona 86002

Cooperative Agreement 9-FC-40-07940

June 1998

## INTRODUCTION

The Little Colorado River (LCR) is the main spawning site for the endangered humpback chub (*Gila cypha*) in the Colorado River (CR), Grand Canyon, and the only spawning area from which fish are recruited into the adult population (Kubly 1990; Valdez and Ryel 1995; AGFD 1996). Other native fishes, bluehead sucker (*Catostomus discobolus*), flannemouth sucker (*C. latipinnis*) and speckled dace (*Rhinichthys osculus*), also spawn in the LCR (Robinson et al. 1996). Extensive research in the LCR during the past decade has provided information on life history and population estimates for humpback chub (Kaeding and Zimmerman 1983; Minckley 1988; 1989; Douglas and Marsh 1996), habitat use by larval native fishes (Gorman 1994; Robinson et al. 1996), movement of native fishes (Douglas and Marsh 1996), age and growth (Robinson and Clarkson 1992), larval drift (Robinson et al. 1996), diet (Robinson and Clarkson 1992) and temporal changes in species composition, frequency and distribution (Robinson and Clarkson 1992; Mattes 1993; Robinson et al. 1996).

In 1996, AGFD continued monitoring native and non-native fishes in the LCR, particularly the spawning populations of humpback chub, bluehead sucker and flannemouth sucker. This report summarizes our results, providing information regarding total catch, catch-per-unit-effort (CPUE), species composition, size class structure, movement and growth of fishes inhabiting the LCR.

## STUDY SITE

The study area consisted of the lower LCR, 1200 m upstream from its confluence with the CR (Figure 1). The LCR in the area of study has a channel that is often deeply entrenched in a vertical-walled canyon, that in places, narrows to less than 50 m. The river contains deep pools and runs, littered with large boulders and a silt/sand bottom, riffles and small rapids.

## METHODS

Native fishes were monitored from 18 April - 20 May. Thirteen standardized AGFD hoop net (6.3 mm mesh, 2-5 m long, 1.0 m diameter of largest hoop) sites in the lower 1200 m

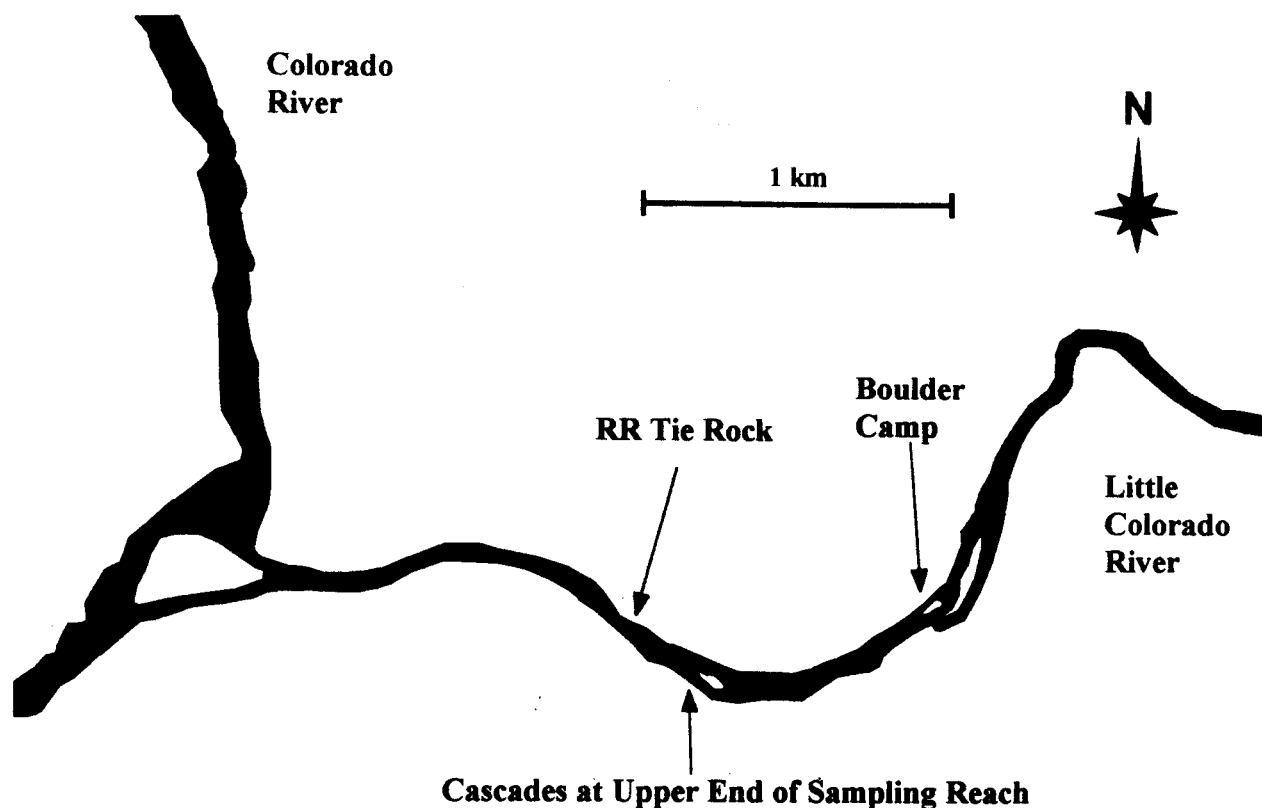


Figure 1. Sample reach used by AGFD during native fish spring monitoring in the Little Colorado River, 1996.

were sampled twice daily, continuously throughout the sampling period. Additional sites in the lower 1200 m were sampled, also twice daily, using minnow traps (0.5 m long, 8 mm mesh) and mini-hoop nets (3.2 mm mesh, 0.45 m long, 50 cm diameter).

Hoop nets were set at 100, 119, 137, 165, 192, 200, 380, 410, 577, 621, 1045, 1110 and 1195 m upstream from the confluence (Figure 1). A total of nine mini-hoop nets was set at 500, 540, 725, 735, 890, 995, 1080, 1135, and 1200 m. Minnow traps were also used to sample fishes and were deployed at 420, 495, 530, 620, 625, 660, 670, 680, 1000, 1125 and 1198 m. Catch-per-unit-effort of all gear types was calculated as number of fish caught/12 h.

All fish collected were identified to species, measured for total length (TL; mm) and weighed (g). Standard length was also measured for humpback chub. Native fish were sexed whenever possible and, if  $\geq 150$  mm TL, scanned for the presence of PIT tag. If a PIT tag was not found, one was inserted into the fish. Information related to mark or recapture and PIT tag number was recorded.

## RESULTS AND DISCUSSION

A total of 4,392 fish of ten species was captured in the LCR in 1996 (Table 1). Speckled dace was the most common species caught (1,353) and comprised 30.9 % of the total catch. Fathead minnow (*Pimephales promelas*) comprised 26.2 % of the catch with 1,144 fish being caught. A total of 919 (21.1 %) bluehead sucker, 549 (12.6 %) humpback chub 276 (6.3 %) and flannelmouth sucker were also caught. Five additional non-native species were also caught: common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), plains killifish (*Fundulus zebrinus*), rainbow trout (*Oncorhynchus mykiss*) and red shiner (*Cyprinella lutrensis*), comprising 2.8 % of the catch, combined.

In 1996, the total catch (4,392) and number of species caught (10) were higher than in 1987 - 1995 (AGFD unpublished data). However, species composition for all native fishes was lower, with large numbers of non-native species being caught.

A total of 334 fish  $\geq 150$  mm were captured; we implanted PIT tags into 198 fish (marked) and 136 had been previously tagged (recaptured) (Table 2). Bluehead sucker had the lowest recapture rate (6.3 %), while 63.6 % of the humpback chub and 33.8 % of flannelmouth suckers were recaptures.

### Native Species

#### *Bluehead sucker*

Bluehead sucker caught in 1996 had a mean length of 62.6 mm TL and mean weight of 10.4 g (Table 3). Several size classes of bluehead sucker were caught in 1996. The majority of the catch was comprised of age 1 fish in the 5 cm modal length class (Figure 2). Adults 151 - 304 mm TL were also caught, but in smaller numbers.

A total of 32 bluehead suckers  $\geq 150$  mm TL was scanned for the presence of PIT tags. Thirty fish were implanted with a PIT tag (Table 4). Two were recaptures, but information regarding initial mark of these fish was unavailable (Table 5).

Adult bluehead sucker mean CPUE in 1996 was 0.46 fish/12 h compared to 0.02 - 0.30 fish/12 h from 1987 - 1994 (AGFD unpublished data). Catch-per-unit-effort of adult bluehead sucker increased with sampling period with the highest CPUE (3.4 fish/12 h) occurring during 9 - 20 May (Figure 3). In addition, the frequency of ripe (expressing gametes) adult

bluehead suckers decreased over the sampling period, indicating that spawning may have occurred prior to our sampling period. The highest mean CPUE of adult bluehead suckers (9 - 20 May) may represent post-spawn adults returning to the mainstem CR.

### *Flannemouth sucker*

Flannemouth sucker had a mean length of 287.9 mm TL and mean weight of 383.1 g (Table 3). As with bluehead sucker, several size classes of fish were caught in the spring of 1996. Young-of-year (YOY) (4 cm modal length class), age 1 (14 cm modal length class) and adult (> 250 mm) age classes were present (Figure 2).

One hundred ninety-five flannemouth suckers  $\geq 150$  mm TL were scanned for the presence of PIT tags. Of these, 129 were marked (Table 6) and 66 were recaptures. Original mark information was obtained for 38 of these recaptures (Table 7). Flannemouth sucker growth rate ranged from 0.5 - 9.9 mm TL/30 days and 6.5 - 120.8 mm TL/year (Table 8). Flannemouth sucker are known to move long distances (Weiss 1993; Valdez and Ryel 1995; Brouder and Hoffnagle 1997; Thieme 1997) and fish caught in the LCR in 1996 had a mean displacement of 86.1 km over an average of 759 days at-large. Thieme (1997) documented two types of movement patterns in flannemouth sucker: local and long-distance; and suggested that these movements may be attributed to spawning and/or food availability, depending on season.

Adult flannemouth sucker had a mean CPUE of 3.0 fish/12 h in 1996, higher than CPUE's from 1987 - 1994 (AGFD unpublished data). Catch-per-unit-effort of adult flannemouth suckers, as with bluehead suckers, increased during the sampling period (Figure 3) and the frequency of mature adults also decreased with sampling period. The presence of YOY flannemouth sucker during this sampling period, in conjunction with highest CPUE and lowest frequency of mature adults during the last sampling period indicates that adult flannemouth sucker also spawned prior to our sampling. The high CPUE of adult flannemouth sucker during 9 - 20 May may also represent post-spawn adults returning to the mainstem CR.

### *Humpback chub*

Humpback chub caught during spring monitoring in the LCR in 1996 had a mean total length of 116.5 mm, mean standard length of 105.0 mm and mean weight of 64.1 g (Table 3). Three size classes of humpback chub were present: YOY (4 cm modal length class), subadult (19

cm modal length class) and adult fish ( $> 200$  cm; Figure 2). In comparison to numbers of YOY caught, adult humpback chub catch was low.

A total of 107 humpback chub  $\geq 150$  mm TL was scanned for the presence of a PIT tag. Of these, 39 were marked (Table 9) and 68 were recaptures (Table 10). Growth rates of 39 humpback chub ranged from 0.1 - 2.4 mm TL/30 days and 0.7 - 29.6 mm TL/year (Table 11). Growth rates of humpback chub caught in the LCR in 1996 were similar to those reported for humpback chub in the LCR in 1992 (6 - 17 mm/year; Minckley 1992). Valdez and Ryel (1995) found slightly higher growth rates of humpback chub in the mainstem Colorado River and concluded that YOY have higher growth rates in the LCR, whereas adults have higher growth rates in the mainstem Colorado River. Meretsky et al. (*in review*) documented higher condition of adult humpback chub in the mainstem Colorado River than in the LCR. This was attributed to food availability and the temperature and flow regime of the Colorado River, thus possibly explaining the difference in growth as well. However, Hoffnagle et al. (1998) reported that YOY and juvenile ( $< 150$  mm TL) humpback chub from the LCR had a lower condition factor, were more likely to be infected by both *Bothriocephalus acheilognathi* (Cestoda) and *Lernaea cyprinacea* (Copepoda) and had a greater mean number of *Lernaea*/fish than those from the mainstem CR. These data indicate that in 1996, conditions in the LCR were not optimum for juvenile humpback chub growth, health or survival.

Humpback chub were at-large an average of 1197 days and moved an average of 0.69 km during that period. Valdez and Ryel (1995) reported that humpback chub exhibit strong spatial fidelity to certain habitat types. Mean displacement of humpback chub caught in the LCR in 1996 was relatively low, but within the range of .05 - 8 km reported by Valdez and Ryel (1995), and further supports spatial fidelity by humpback chub.

Catch-per-unit-effort of adult humpback chub in 1996 was 1.35 fish/12 h; a large increase from 1994 (0.11 fish/12 h) but within the range of 0.11 - 2.22 fish / 12 h from 1987 - 1994 (AGFD unpublished data). As reported for bluehead and flannelmouth sucker, CPUE of adult humpback chub also increased during the sampling period (Figure 3) and the frequency of ripe adults decreased. The presence of YOY during this sampling period, in conjunction with highest CPUE and lowest frequency of mature adults during the last sampling period also indicates that adult humpback chub had spawned prior to our sampling and may have been returning to the mainstem CR, as seen for the suckers.

*Speckled dace*

Speckled dace caught in the LCR during spring monitoring had a mean length of 58.3 mm TL and mean weight of 2.1 g (Table 3). All speckled dace caught were age 1 adults (Figure 2). No YOY were caught, indicating that speckled dace spawning may not have occurred during our sampling period. John (1963) determined that speckled dace spawning occurs once in a short period in late spring or early summer in streams in the Chiricahua Mountains, AZ. Minckley (1991) and AGFD (1996) reported that young speckled dace are abundant in late May to early June in Grand Canyon. In Utah, speckled dace spawn throughout the summer with a peak in June and July when water temperature reaches 18° C (Sigler and Sigler 1996). In the LCR, spawning probably begins earlier than in Utah and data from the mainstem CR indicate that speckled dace spawn throughout the summer (AGFD 1996).

Non-native Species*Red shiner*

A total of 29 red shiner, comprising 1 % of the total catch, was caught in 1996. Red shiner had a mean length of 54.6 mm TL and mean weight of 1.7 g (Table 3). All red shiners caught were age 1 and the modal length class was 5 cm (Figure 4).

Red shiner is a non-native species that may compete with natives for food and/or habitat and prey on larval native fishes (Minckley 1973). Red shiners were caught in only 1 of 7 (1989) years of previous sampling in the LCR, and comprised 0.1 % of the total catch (Robinson and Clarkson 1992; AGFD unpublished data). The increased prevalence of red shiners in the catch and their documented piscivory (Ruppert et al. 1993) is of concern and needs to be monitored.

*Common carp*

Sixty-two common carp, comprising 1.4 % of the total catch, was caught in the LCR during spring monitoring. Adult spawning activity was observed along vegetated shorelines on several occasions. Common carp had a mean length of 55.5 mm TL and mean weight of 17.8 g (Table 3). Young-of-year (3 cm modal length class) sub-adults (162 - 174) and adults (231 - 298 mm TL) were collected in 1996 (Figure 4).

The effects of common carp on other fishes is often subtle (Minckley 1973). Although they rarely feed on other fishes, they may raid nests and feed on eggs and compete for food and

habitat with native fishes.

### *Plains killifish*

Forty-eight plains killifish were caught, comprising 1.1 % of the catch. All plains killifish were age 1, had a mean length of 56.3 mm TL and mean weight of 1.6 g (Table 3). The modal length class was 6 cm (Figure 4).

Sigler and Sigler (1996) reported that plains killifish are omnivorous, but mainly consume food from the surface. Conversely, Minckley and Klaason (1969) reported that plains killifish foraged on the bottom, consuming primarily chironomids. In backwaters of the CR, plains killifish feed at all levels (AGFD 1996). Therefore, plains killifish in the LCR may compete with larval and juvenile native fishes for food in nearshore slackwater areas. However, low numbers and restricted habitat may reduce their impact on native fishes.

### *Fathead minnow*

Fathead minnow was the most commonly caught non-native species during 1996. Fathead minnow had a mean length of 64.6 mm TL and mean weight of 3.2 g (Table 3). They were all age 1 adults and the modal length class was 6 cm (Figure 4).

Fathead minnow comprised 36.2 % of the catch in 1996 compared to a high of 2.4 % in 1987 - 1995. Higher numbers of fathead minnows in 1996 may be attributed to the implementation of minnow traps (set in nearshore habitats) during 1996, although large numbers were caught in hoop nets, as well. Nonetheless, fathead minnows comprised higher portions of the catch than native fishes, except speckled dace, in 1996. Fathead minnow have been shown to prey on catostomid larvae (Dunsmoor 1993), and may also compete with natives for food and/or habitat (Minckley 1973). Arizona Game and Fish Department (1996) found that fathead minnow and juvenile native fishes consumed many of the same items, including midge larvae, cladocerans, nematodes, simuliids and terrestrial insects.

### *Other species*

Two channel catfish (< 1%; 310 and 630 mm TL) and 10 rainbow trout were also caught. Rainbow trout comprised < 1 % of the total catch and had a mean length of 331.6 mm TL and mean weight of 376.1 g (Table 3). Both channel catfish and rainbow trout have been shown to



prey on all four native fish species found in the LCR (Valdez and Ryel 1995; Marsh and Douglas 1997) and their numbers should continue to be monitored. Additionally, efforts to reduce their numbers should be considered.

## SUMMARY

Mean CPUE's of adult bluehead sucker, flannemouth sucker and humpback chub in 1996 were higher than those from 1987 - 1994 (AGFD unpublished data). In fact, mean CPUE of adult native fishes, excluding speckled dace, had been decreasing (AGFD unpublished data). Higher CPUE's of adult native fishes were welcomed in 1996 and may be indicative of successful recruitment from past year classes.

Based on mean CPUE's of adults throughout the sampling period, the reduced frequency of mature adults and the presence of YOY in the catch, we conclude that the spawning season of humpback chub, flannemouth sucker and bluehead sucker may have occurred earlier than our sampling period. The higher CPUE of these adult native fish later in the sampling period, and the simultaneous decrease in the percentage of ripe fish may represent post-spawn adults returning downstream to the mainstem CR. Robinson et al. (1996) documented large overlap and variability in spawning time and duration among native fishes. Perhaps the low catch and downward trend in mean CPUE of adult native fishes from 1987 - 1994 may be attributed to frequently missing the peak spawning time.

Monitoring of all native and non-native species in the LCR should be continued, especially because of the LCR's importance to the remaining native fishes. Data from the past decade have shown a change in species composition with non-native fish abundance increasing. Predation by large non-native fishes may significantly affect the native species by depleting numbers and reducing recruitment (Marsh and Douglas 1997). To address this problem, AGFD has proposed to conduct a predator removal study for large predators in the LCR. However, small predatory/competitive non-native fishes may be more detrimental to native species but more difficult to control. With increasing numbers of non-native fish species entering the system, some type of effort to eradicate or reduce their numbers should be considered.

Table 1. Total number caught and percent composition for each species caught during spring monitoring in the Little Colorado River, 1996.

Species	Total Number Caught	Percent Composition
Bluehead sucker	919	21.1
Flannemouth sucker	276	6.3
Humpback chub	549	12.6
Speckled dace	1,353	30.9
Channel catfish	2	< 1.0
Common carp	62	1.4
Fathead minnow	1,144	26.2
Plains killifish	48	1.1
Rainbow trout	10	< 1.0
Red shiner	<u>29</u>	1.0
Total Caught	4,365	

Table 2. Total number of fish  $\geq 150$  mm TL caught, marked and recaptured and percent recapture for bluehead sucker, flannemouth sucker and humpback chub caught in the Little Colorado River during spring monitoring, 1996.

Species	Total number caught $\geq 150$ mm TL	Number Marked	Number Recaptured	Percent Recaptured
Bluehead sucker	32	30	2	6.3
Flannemouth sucker	195	129	66	33.8
Humpback chub	107	39	68	63.6

Table 3. Mean, minimum and maximum total length, standard length for humpback chub and weight for each species caught in the Little Colorado River during spring monitoring, 1996.

Species	Total Length (mm)			Standard Length (mm)			Weight (g)	
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Maximum
Bluehead sucker	62.6	22	305				10.4	0.1
Flannelmouth sucker	287.9	17	516				383.1	1.8
Humpback chub	116.5	15	656	105.0	18	196	64.1	0.3
Speckled dace	58.3	14	108				2.1	0.1
Channel catfish	470.0	310	630				274.0	-
Common carp	55.5	23	299				17.8	0.1
Fathead minnow	64.6	20	90				3.2	0.1
Plains killifish	56.3	44	67				1.6	1.0
Rainbow trout	331.6	71	422				376.1	3.9
Red shiner	54.6	45	70				1.7	1.2
								2.2

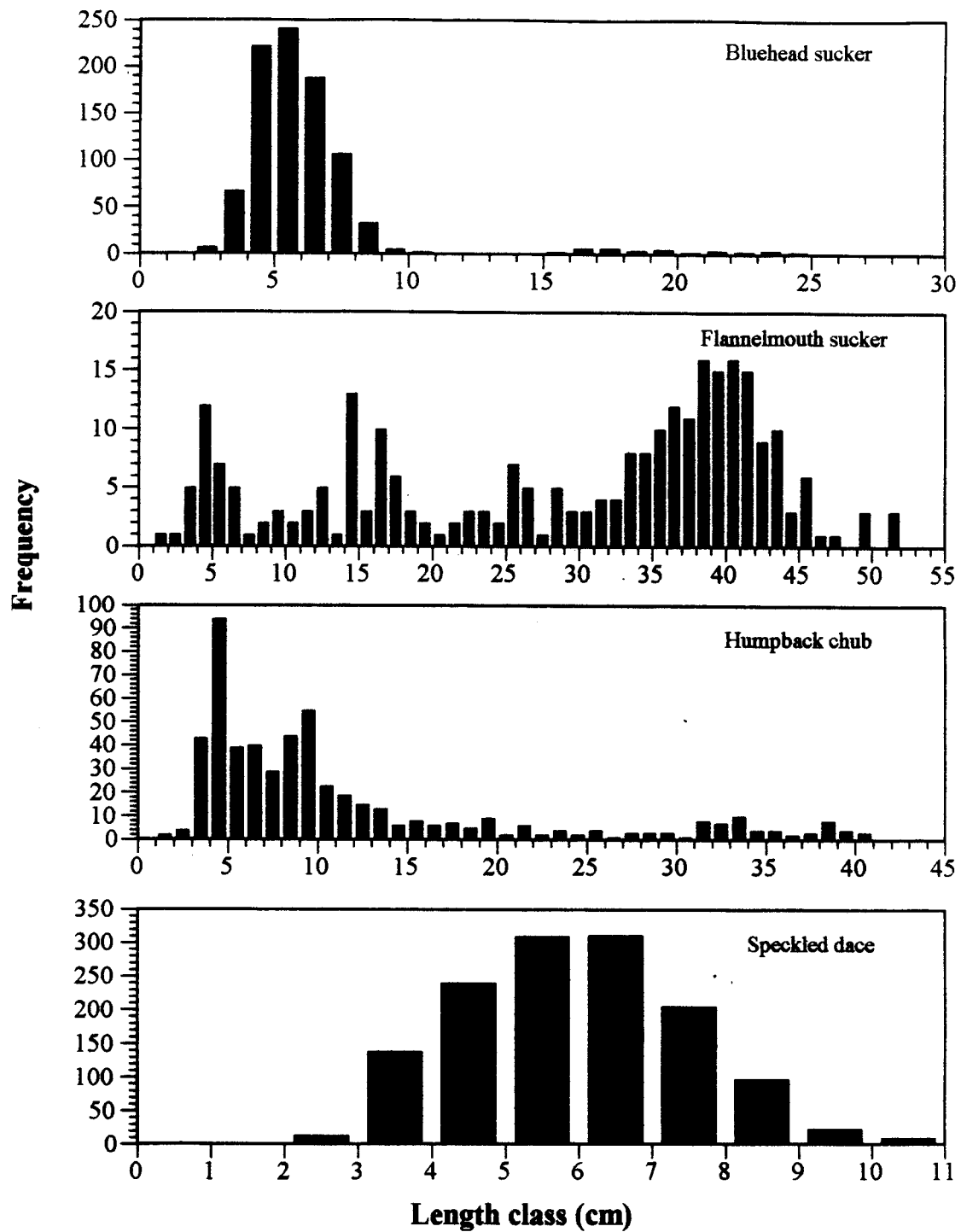


Figure 2. Length frequency of native fishes caught in the Little Colorado River during spring monitoring, 1996.

Table 4. Capture location (distance upstream from mouth), total length, weight and sex of bluehead sucker implanted with a PIT tag during spring monitoring in the Little Colorado River, 1996.

Capture Location (m)	Date	Total Length	Weight	Sex	PIT Tag Number
1200	19 APR 96	150	35.0	F	1F78330036
1200	19 APR 96	168	63.0	F	1F7A300037
1135	21 APR 96	175	53.0	F	1F78785021
380	21 APR 96	185	60.0	F	1F783F3C6E
100	21 APR 96	198	68.0	M	1F781F3C0E
1160	21 APR 96	220	96.0	F	1F7778777B
1160	21 APR 96	167	48.0	F	1F7A3D1218
540	23 APR 96	283	242.0	M	1F78421D0A
1110	23 APR 96	164	46.0	F	1F782E2D0E
1160	24 APR 96	209	79.0	F	1F7A1F2A1E
890	24 APR 96	190	72.0	M	1F7A7C7E6D
137	25 APR 96	163	45.0	F	1F7B015E07
1080	25 APR 96	179	61.0	M	1F777F3B30
1135	26 APR 96	177	52.0	M	1F7A31486E
200	26 APR 96	243	125.0	F	1F77715821
1110	26 APR 96	248	142.0	U	1F7A3D5951
200	26 APR 96	235	126.0	F	1F7A1C3912
1190	26 APR 96	219	101.0	F	1F7A3D200A
1135	27 APR 96	195	68.0	U	1F78242520
1135	27 APR 96	162	37.0	M	1F780E4417
1160	28 APR 96	305	-	U	1F77725D28
119	11 MAY 96	236	162.0	U	7F7A13786E
1045	11 MAY 96	217	109.3	U	1F3E586D5E
165	12 MAY 96	192	62.8	U	7F7A136F75
577	13 MAY 96	211	89.3	U	1F3E557658
200	15 MAY 96	214	71.1	U	7F7D3D665A
100	15 MAY 96	179	45.6	U	7F7A136224
380	16 MAY 96	179	56.4	U	7F7B190C45
165	17 MAY 96	189	61.6	U	7F7B190E13
502	17 MAY 96	181	51.1	M	7F7A12563A

Table 5. Capture location, length, weight and sex, as well as location, length, weight and date of original marking and previous capture of bluehead sucker recaptured with a PIT tag during spring monitoring in the Little Colorado River, 1996.

PIT tag Number	Recapture			Mark		
	Date	Capture Location*	Total Length	Weight	Sex	Date
1F7B5A6B21	24 APR 96	540	265	196	F	
1F7874373E	19 APR 96	192	231	111	M	

\* meters upstream

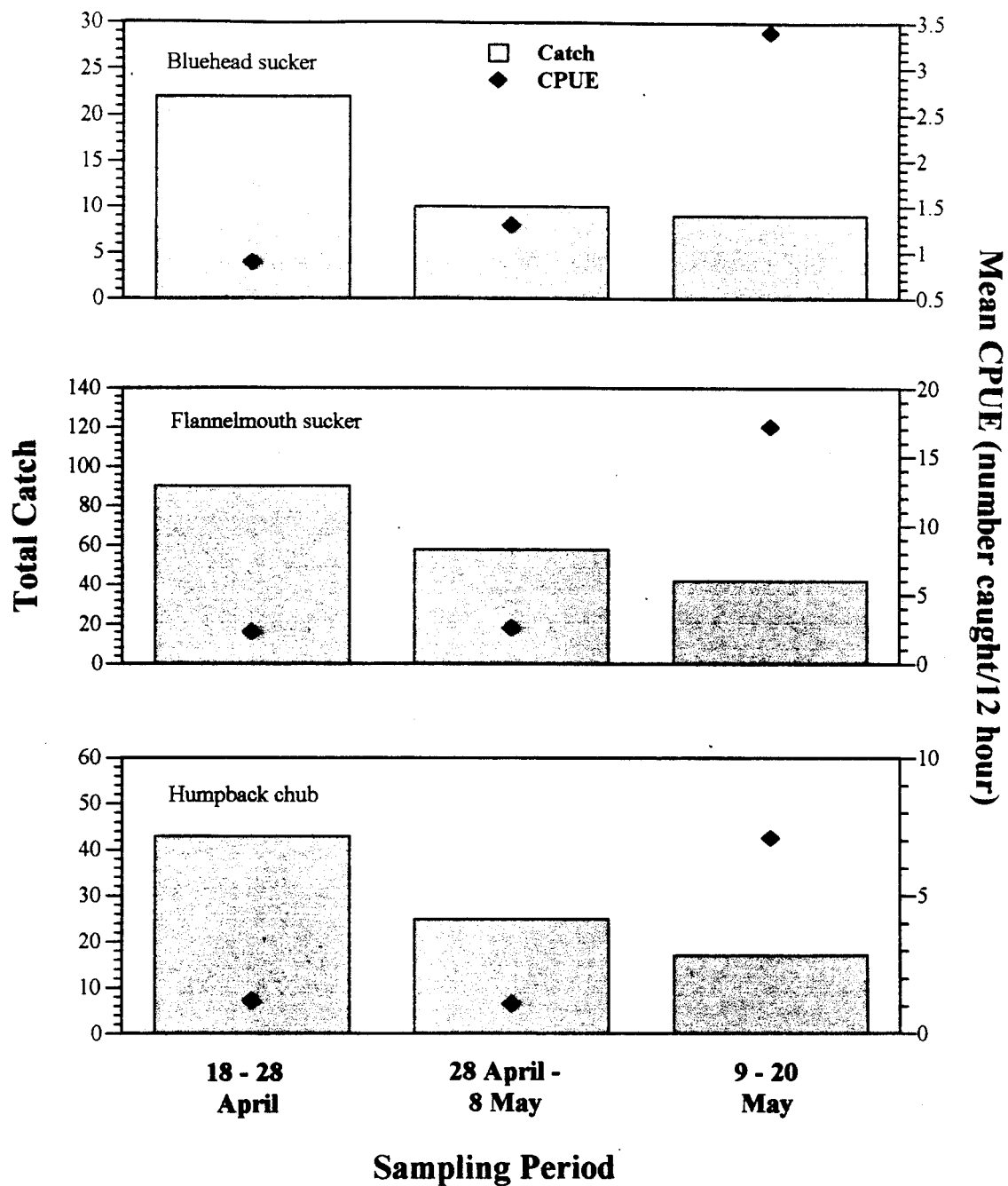


Figure 3. Total catch and mean CPUE (number caught/12 hours) for adult bluehead sucker, flannemouth sucker and humpback chub caught in the Little Colorado River during spring monitoring, 1996.

Table 6. Capture location (distance upstream from mouth), total length, weight and sex of flannelmouth sucker implanted with a PIT tag during spring monitoring in the Little Colorado River, 1996.

Capture Location (m)	Date	Total Length	Weight	Sex	PIT Tag Number
200	16 APR 96	341	116	U	1F7A773838
165	18 APR 96	378	574	M	1F7A76620F
165	18 APR 96	405	528	F	1F7777482B
165	18 APR 96	379	614	F	1F7A20291E
165	18 APR 96	390	554	M	1F77771A59
165	18 APR 96	370	431	F	1F7B60087E
165	18 APR 96	435	671	M	1F7B0B0853
165	19 APR 96	434	690	M	1F7A731B59
165	19 APR 96	280	199	F	1F7B624C38
165	19 APR 96	405	620	M	1F78286A57
165	19 APR 96	346	429	M	1F7B49633A
165	19 APR 96	333	351	M	1F7B601670
165	19 APR 96	338	377	F	1F7B624C38
577	19 APR 96	178	50	F	1F7B6A6D0F
1200	19 APR 96	205	69	F	1F7B573659
500	20 APR 96	160	37	F	1F7A767E73
577	20 APR 96	151	31	F	1F777F0E5D
165	21 APR 96	313	317	M	1F777E1359
165	21 APR 96	281	203	F	1F7B585B33
119	21 APR 96	430	751	M	1F7A2C4378
165	21 APR 96	413	565	F	1F77733641
165	22 APR 96	470	962	M	1F7B026B79
165	22 APR 96	452	884	F	1F7B4F6F28
165	22 APR 96	415	628	M	1F7B0A5C00
200	22 APR 96	364	385	F	1F7B105600
165	22 APR 96	370	465	M	1F7B084F0F
165	22 APR 96	375	437	M	1F78172C26
420	22 APR 96	150	29	F	1F783A2D02
165	22 APR 96	428	731	F	1F78333F77
165	22 APR 96	385	542	F	1F78003D2C
165	22 APR 96	381	482	M	1F7A2E0A2F
165	23 APR 96	380	425	F	1F7A1C7655
165	22 APR 96	369	422	M	1F7B067C64
165	23 APR 96	367	410	M	1F78307C3D



Table 6 (cont'd).

Capture Location (m)	Date	Total Length	Weight	Sex	PIT Tag Number
119	23 APR 96	193	66	F	1F7A2F4672
119	23 APR 96	193	66	F	1F7A2F4672
192	23 APR 96	252	130	M	1F777B4728
380	23 APR 96	175	48	M	1F5B7C1C6E
1160	23 APR 96	229	104	F	1F7B493568
137	24 APR 96	174	49	F	1F78310137
165	25 APR 96	233	108	M	1F7A2C7C3F
119	25 APR 96	280	209	M	1F7B6A403C
165	25 APR 96	292	261	F	1F7A7D2A40
165	25 APR 96	291	230	M	1F6B04086A
165	25 APR 96	302	282	F	1F7A336153
165	25 APR 96	311	292	M	1F7A38347B
165	25 APR 96	345	416	M	1F7A1D7258
165	25 APR 96	354	425	M	1F7B0D6574
165	25 APR 96	387	531	M	1F7B575738
165	25 APR 96	425	415	F	1F7A7B7973
165	25 APR 96	426	649	M	1F78084D14
165	25 APR 96	393	647	M	1F78400623
165	25 APR 96	384	505	M	1F7B02184C
165	25 APR 96	499	1240	F	1F78312513
165	26 APR 96	492	1020	F	1F7839743C
165	26 APR 96	380	463	F	1F785E0404
165	25 APR 96	250	145	F	1F7A282A15
165	26 APR 96	433	698	M	1F77716D0C
165	26 APR 96	255	165	F	1F7B4B7625
165	26 APR 96	263	176	M	1F7A7D0F5B
200	26 APR 96	263	184	M	1F7B527A1A
165	26 APR 96	337	328	F	1F78145302
165	26 APR 96	408	578	M	1F7B562769
165	26 APR 96	360	449	F	1F7B510C09
165	26 APR 96	240	133	F	1F783F2D7D
119	27 APR 96	187	60	F	1F78004F1A
119	27 APR 96	253	155	F	1F78091F41
200	27 APR 96	302	269	M	1F77725325
119	27 APR 96	271	162	F	1F782B6F4R
119	27 APR 96	164	41	F	1F777F1259

Table 6 (cont'd).

Capture Location (m)	Date	Total Length	Weight	Sex	PIT Tag Number
200	28 APR 96	390	624	M	1F7B482D71
200	29 APR 96	422	232	U	1F783E210A
165	29 APR 96	430	-	U	1F7B54781A
200	29 APR 96	359	136	U	1F7B504650
165	29 APR 96	328	-	U	1F7A777F71
165	29 APR 96	269	-	U	1F7A274C74
165	1 MAY 96	363	438	U	1F78147E57
165	1 MAY 96	359	-	U	1F78277949
165	1 MAY 96	258	154	U	1F7B515144
165	1 MAY 96	253	134	U	1F7829734D
165	1 MAY 96	412	544	U	1F7B02273D
165	1 MAY 96	382	-	U	1F780E7863
200	1 MAY 96	240	-	U	1F78440124
200	2 MAY 96	355	-	U	1F7A331024
165	2 MAY 96	332	294	U	1F7836684B
200	3 MAY 96	333	-	U	7F7D3D684B
200	3 MAY 96	350	-	U	7F7D7F452A
165	3 MAY 96	401	-	U	1F7B68126C
165	3 MAY 96	381	-	U	1F7A3D2A00
165	3 MAY 96	289	-	U	1F7B4B3665
165	4 MAY 96	431	-	U	1F7B5D3059
165	4 MAY 96	351	-	U	1F7B631073
165	7 MAY 96	451	-	U	7F7B07280D
119	7 MAY 96	416	-	U	7F7B18566B
119	7 MAY 96	415	-	U	7F7D7F493A
119	7 MAY 96	422	-	U	1F782D4577
165	7 MAY 96	267	-	U	7F7A16692D
165	9 MAY 96	419	774	M	7F7D7F3A19
200	9 MAY 96	415	686	F	7F7A121F3B
165	10 MAY 96	426	714	F	1F3E6D0531
165	10 MAY 96	413	612	M	1F3C1F7115
165	10 MAY 96	441	832	F	7F7B197210
165	10 MAY 96	406	666	M	1F3E6C6C4B
165	10 MAY 96	378	540	M	7F7D7F4525
410	10 MAY 96	162	36	U	7F7B197970
100	11 MAY 96	161	33	U	7F7A136944

Table 6 (cont'd).

Capture Location (m)	Date	Total Length	Weight	Sex	PIT Tag Number
165	11 MAY 96	409	578	M	7F7B073C73
165	11 MAY 96	384	490	M	7F7B073A03
119	11 MAY 96	392	512	F	7F7B072945
190	11 MAY 96	168	38	U	1F3E65102E
1190	11 MAY 96	161	31	U	7F7B1A022C
165	12 MAY 96	294	183	M	7F7B1A0540
190	12 MAY 96	176	39	U	7F7D1D5029
165	13 MAY 96	405	772	F	7F7B190549
165	13 MAY 96	414	710	F	1F3C14246D
165	13 MAY 96	374	584	F	1F3E545778
165	13 MAY 96	452	936	F	7F7B193957
165	13 MAY 96	428	872	M	7F7B1A047A
165	13 MAY 96	399	772	F	7F7D7F402C
1190	13 MAY 96	152	30	U	7F7A136B7D
165	14 MAY 96	516	1000	F	1F3E621A27
190	15 MAY 96	228	96	U	7F7B190476
165	15 MAY 96	356	472	F	7F7B190258
165	15 MAY 96	381	513	F	7F7D7F360A
165	16 MAY 96	385	564	M	7F7D7F4B53
165	16 MAY 96	396	232	F	7F7B072E4C
165	16 MAY 96	443	320	M	1F3E615072
165	16 MAY 96	401	598	F	1F3E61360C
165	16 MAY 96	401	544	F	7F7B182F69

Table 7. Capture location, length, weight and sex as well as location, length, weight and date of original marking and previous capture of flannemouth sucker recaptured with a PIT tag during spring monitoring in the Little Colorado River, 1996.

PIT Tag Number	Recapture					Mark				
	Date	Capture Location	Total Length	Weight	Sex	Date	Capture Location	Total Length	Weight	
1F7B6A6D0F	9 MAY 96	410	187	55	U					
1F78366E45	27 APR 96	165	250	136	F					
7F7D7F406D	30 APR 96	119	265	164	U	28 MAR 95	LCR	182	50	
7F7B196E17	19 APR 96	165	287	254	M	4 NOV 94	LCR	185	42	
1F782F7F3B	30 APR 96	200	302	258	U	8 APR 95	HAV	231	130	
1F73E554608	27 APR 96	119	313	320	M					
1F7B132D26	27 APR 96	165	310	203	F	3 MAR 96	LCR	307	306	
7F7A12447B	23 APR 96	165	324	366	M	9 MAY 95	LCR	249	141	
7F7A16702C	16 MAY 96	165	324	286	M					
	1 MAY 96	165	325	294	U					
	7 APR 95	KAN	257	175	U	28 MAY 94	KAN	207	85	
7F7B1A0127	25 APR 96	200	331	324	M	22 JUN 94	LCR	178	48	
1F7B634043	30 APR 96	200	337		U					
1F7B0C2A30	25 APR 96	165	334	345	M					
1F783F4862	29 APR 96	165	349		U					
7F7B185059	21 APR 96	165	356	442	M	14 MAY 94	LCR	156	28	
1F3E6B5662	1 MAY 96	165	346	376	U	7 NOV 94	LCR	167	32	

Table 7 (cont'd).

PIT Tag Number	Recapture					Mark			
	Date	Capture Location	Total Length	Weight	Sex	Date	Capture Location	Total Length	Weight
1F3C1C3C4D	23 APR 96	165	356	360	M	17 JUN 94	LCR	193	58
1F7B071B44	25 APR 96	165	354	456	M				
1F78262D16	9 MAY 96	165	368	588	F				
1F782D5F5D	20 APR 96	165	363	414	M	5 NOV 94	LCR	213	58
1F780A055A	22 APR 96	165	362	504	M				
1F200D0F25	22 APR 96	165	367	451	M				
7F7B1B1D72	29 APR 96	165	363		U				
7F7D075D31	4 MAY 96	165	362		U				
1F1F674219	11 MAY 96	165	376	576	F	7 JUN 94	LCR	195	51
1F3E61340E	11 MAY 96		379	525	F				
	11 JUN 95	LCR	325	320	U	28 MAY 94	KAN	257	164
1F466F5C50	26 APR 96	165	375	519	M	20 APR 94	LCR	187	44
1F78412A7E	10 MAY 96	165	388	572	M	9 JUN 94	LCR	240	-
7F7B073736	19 APR 96	165	382	543	F				
1F7B5F7F08	29 APR 96	165	380		U	23 JUN 95	KAN	330	296
1F3E70347F	3 MAY 96	165	389	479	U	28 MAR 95	LCR	266	174

Table 7 (cont'd).

PIT Tag Number	Recapture					Mark			
	Date	Capture Location	Total Length	Weight	Sex	Date	Capture Location	Total Length	Weight
1F7838022F	18 APR 96	165	398	562	M				
1F7B515C39	22 APR 96	165	395	578	M	1 MAR 96	LCR	383	581
7F7A1A6026	29 APR 96	165	398		U				
1F78422601	3 MAY 96	165	390	438	U	16 MAY 94	LCR	215	84
1F7B022717	3 MAY 96	165	391	486	U				
1F78317B3D	3 MAY 96	165	396		U				
1F7B6E4434	9 MAY 96	200	396	624	M	2 FEB 96	LCR	392	582
7F7B182E36	21 APR 96	200	398	585	M	8 NOV 94	LCR	251	118
7F7B073721	30 APR 96	200	391	472	U	8 NOV 94	LCR	225	66
7F7D4B6F58	17 MAY 96	119	406	534	F	7 MAY 93	LCR	156	31
7F7B197008	13 MAY 96	165	403	504	F	8 APR 95	HAV	386	525
1F7A7C717A	19 APR 96	165	400	540	F	1 FEB 96	LCR	380	562
1F7B4B4754	21 APR 96	165	400	598	F				
7F7B150B23	23 APR 96	165	401	552	M	28 MAY 93	191.92*	188	62
1F78011058	3 MAY 96	165	401		U				
1F0F6C3135	23 APR 96	200	402	543	M	15 OCT 93	LCR	155	26
7F7A135A1F	7 MAY 96	119	415		U	19 APR 94	LCR	245	130

Table 7 (cont'd).

PIT Tag Number	Recapture					Mark			
	Date	Capture Location	Total Length	Weight	Sex	Date	Capture Location	Total Length	Weight
1F7A754D25	9 MAY 96	165	413	684	M	17 SEP 95	63.5*	365	454
1F78004524	10 MAY 96	165	411	628	M	20 APR 96	62.25*	405	652
7F7A136C74	19 APR 96	165	412	592	F				
1F7B0F4017	22 APR 96	200	415	217	U				
1F77712752	13 MAY 96	165	426	748	F	1 FEB 96	61.5*	411	665
7F7D1C301F	10 MAY 96	165	446	778	M	21 APR 93	KAN	358	422
7F7F2A1A0E	7 MAY 96	119	457		M				
7F7B081D6C	18 APR 96	165	458	833	F				
7F7A141565	18 APR 96	165	432	714	F	28 MAY 94	KAN	312	296
7F7D225C1D	19 APR 96	165	435	741	F	28 MAY 93	192.4*	155	36
1F7B497429	29 APR 96	165	430		U				
1F3C1D25631	14 MAY 96	165	451	684	F				
1F46611822	7 MAY 96	119	515		F	16 JAN 94	LCR	500	1288
1F7B611D68	7 MAY 96	119	515		F				
7F7D40195E	14 MAY 96	165	493	1000	F	18 MAR 93	PAR	446	950
1F7A2D2218	14 MAY 96	165	460	1000	M	21 APR 96	60.83*	461	992
1F09380B15	16 MAY 96	165	429	836	M				

\* Colorado River Mile

Table 8. Mean and range of days at large, distance traveled and growth rates (length and weight/30 days) of PIT tagged flannemouth sucker and humpback chub recaptured during spring monitoring in the Little Colorado River, 1996.

Species	Days at Large		Distance Traveled (km)		Growth Rate / 30 days			
					Length (mm)		Weight (g)	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Flannemouth Sucker	759	20 - 1153	86.1	0 - 132.5	7.3	0.5 - 9.9	8.5	-3.4 - 17.5
Humpback Chub	1197	716 - 2002	0.7	0 - 4.3	0.7	0.1 - 2.4	2.7	-1.2 - 7.7



Table 9. Capture location (distance upstream from mouth), total length, weight and sex of humpback chub implanted with a PIT tag during spring monitoring in the Little Colorado River, 1996.

Capture Location (m)	Date	Total Length	Weight	Sex	PIT Tag Number
1160	18 APR 96	181	56	U	1F7810322
137	18 APR 96	168	36	U	1F782A2D12
137	19 APR 96	174	46	M	1F7B547121
200	20 APR 96	231	94	M	1F77716217
165	20 APR 96	184	56	M	1F780E0F49
137	21 APR 96	218	89	F	1F7A792747
1110	23 APR 96	232	100	M	1F78244104
100	23 APR 96	151	26	U	1F7A34367D
1070	24 APR 96	201	69	M	1F7A1F2A1E
200	24 APR 96	269	199	F	1F6B31162F
165	24 APR 96	165	40	U	1F7B535C37
119	25 APR 96	194	65	M	1F782E3209
1070	25 APR 96	153	32	U	1F7A1D5B6F
1110	25 APR 96	361	334	F	1F7A7C2546
1160	26 APR 96	406	508	F	1F78403772
200	26 APR 96	229	135	M	1F7B67720D
1135	26 APR 96	198	67	M	1F764B031D
119	26 APR 96	214	85	M	1F7B4C5E3C
165	26 APR 96	167	41	U	1F7B134013
192	29 APR 96	191	29	U	1F7B0A5F7D
119	30 APR 96	176	47	U	1F7B140D45
165	1 MAY 96	215	98	U	1F780D4715
165	1 MAY 96	314	242	U	1F7B5F6225
119	1 MAY 96	181	-	U	1F7B08401E
119	2 MAY 96	232	119	U	1F77751A5E
200	2 MAY 96	350	-	U	1F7B670A75
165	2 MAY 96	165	40	U	1F7A722154
200	4 MAY 96	407	-	U	1F781C103D
190	11 MAY 96	206	80	F	7F7B197239
165	12 MAY 96	197	75	F	7F7A13633D
380	12 MAY 96	197	66	F	7F7B185664
165	12 MAY 96	157	28	M	7F7B071961
200	13 MAY 96	163	29	U	7F7B197456
200	14 MAY 96	226	35	F	7F7B073424

Table 9 (cont'd)

Capture Location (m)	Date	Total Length	Weight	Sex	PIT Tag Number
137	15 MAY 96	176	52	U	7F7A166226
100	16 MAY 96	176	39	U	1F3C1A7615
119	25 MAY 96	351	394	F	1F7A263E03
410	27 MAY 96	189	51	M	1F7B5C0B7F
192	27 MAY 96	325	299	M	1F7B003A2C

Table 10. Capture location, length, weight and sex as well as location, length, weight and date of original marking and previous capture of humpback chub recaptured with a PIT tag during spring monitoring in the Little Colorado River, 1996.

PIT Tag Number	Recapture				Mark			
	Date	Capture Location	Total Length	Weight	Sex	Date	Capture Location	Total Length
1F7B0E5C37	27 APR 96	1070	156	30	F			
1F7A722154	3 MAY 96	380	165		U			
1F7B7140D45	30 APR 96	137	177	47	U			
7F7B037C37	25 APR 96	1160	194	64	M			
1F78306F4A	30 APR 96	119	210	76	U			
1F200C7342	6 MAY 96	200	217		U			
7F7D52163F	26 APR 96	1070	173	47		11 MAY 94	LCR	150
7F7B037C37	27 APR 96	1070	195	67	M			25
	26 APR 96	1070	194	64	M			
	26 APR 96	1070	194	72	M			
	25 APR 96	1060	194	646	M	13 MAY 93	LCR	139
7F7D295823	25 APR 96	200	234	91	M	12 FEB 92	LCR	215
7F7F2D0E17	17 MAY 96	165	254	153	F	15 NOV 92	LCR	155
1F09390817	27 APR 96	380	251	130	M			28
7F7B03797D	1 MAY 96	119	248	188	U			
	1 MAY 96	165	248	130	U	12 MAY 93	LCR	191
7F7B01544A	26 APR 96	165	317	322	F	15 JAN 93	60.4*	300
								264

Table 10 (cont'd).

PIT Tag Number	Recapture					Mark			
	Date	Capture Location	Total Length	Weight	Sex	Date	Capture Location	Total Length	Weight
1F09390817	27APR 96	380	251	130	M				
	26APR 96	200	252	136	M	17 MAY 93	LCR	224	74
7F7D2A7243	24 APR 96	200	317	267	M	10 MAR 92	LCR	273	188
7F7E500B58	25 APR 96	200	310	211	F	17 JUL 91	LCR	211	58
1F01644529	10 MAY 96	380	333	470	F				
7F7F2C0D58	24 APR 96	1070	335	273	M	19 JUN 92	LCR	312	250
7F7D2C0632	26 APR 96	1070	333	301	F	20 AUG 91	LCR	325	278
7F7F27203C	29 APR 96	119	345		U	30 MAR 92	LCR	335	352
7F7F291337	26 APR 96	200	318	283	F	28 APR 92	LCR	293	216
7F7F205501	26 APR 96	200	310	224	F	5 APR 92	LCR	341	126
7F7F173738	25 APR 96	119	326	281	U				
1F20241607	26 APR 96	165	327	311	F				
7F7D077C78	25 APR 96	200	322	266	M	12 APR 92	61.50*	280	241
1F7B5E6D1B	26 APR 96	200	329	335	M				
7F7F3E6339	23 APR 96	1110	324	376	F	19 JUN 92	LCR	253	144
7F7F050368	24 APR 96	119	336	280	M	11 MAY 89	LCR	263	130

Table 10 (cont'd).

PIT Tag Number	Recapture					Mark			
	Date	Capture Location	Total Length	Weight	Sex	Date	Capture Location	Total Length	Weight
1F0F644529	14 MAY 96	165	331	382	F	18 MAY 93	LCR	275	154
7F7F275326	26 APR 96	165	338	314	M	29 MAR 92	LCR	306	274
7F7D090733	1 MAY 96	165	334	278	U	13 SEP 91	62.10*	317	210
1F0F644529	2 MAY 96	165	331	382	U	18 MAY 93	LCR	275	154
1F1F675E7D	2 MAY 96	192	330		U	16 JUN 93	LCR	289	200
7F7D176311	3 MAY 96	200	332		U	18 AUG 91	LCR	275	152
7F7F392149	24 APR 96	1070	254	167	M	23 APR 92	LCR	237	102
7F7E427710	25 APR 96	165	393	425	M	11 MAR 92	LCR	394	494
7F7F33231F	11 MAY 96	119	390	438	M	14 FEB 92	LCR	378	400
7F7D2C094F	13 MAY 96	1160	389	790	F	12 FEB 92	LCR	396	670
7F7B020571	4 MAY 96	200	380		U	16 MAY 93	LCR	384	502
7F7F217F6B	1 MAY 96	200	383		U				
7F7D2C374A	30 APR 96	165	385	394	U	14 FEB 92	LCR	377	416
7F7F37427E	10 MAY 96	100	397	472	M				
	10 SEP 92	58.3	386	449					
	8 SEP 91	58.8	290	468		8 JAN 91	58.8*	386	505
7F7F394531	11 MAY 96	119	386	484	M	2 APR 92	LCR	376	474

Table 10 (cont'd).

PIT Tag Number	Recapture					Mark			
	Date	Capture Location	Total Length	Weight	Sex	Date	Capture Location	Total Length	Weight
7F7F3C6F28	26 APR 96	165	374	411	M	20 APR 90	LCR	370	382
7F7D180530	24 APR 96	1070	384	602	F				
	3 JUN 91	LCR	350	356					
7F7F3E2720	11 MAY 96	119	386	434	F				
	12 SEP 92	60.40	363	435		16 NOV 90	61.20*	355	465
7F7F395437	24 APR 96	1070	373	420	F	12 MAR 92	LCR	345	346
7F7F206606	25 APR 96	165	358	434	M	22 APR 92	LCR	338	313
7F7F21726D	11 MAY 96	119	368	484	F	9 MAR 93	LCR	274	560
7F7F291337	1 MAY 96	119	371	286	U	27 APR 92	LCR	293	216
7F7D181E74	1 MAY 96	200	375		U	17 MAR 93	LCR	366	499
1F7B68512D	11 MAY 96	165	345	308	M				
7F7E432C26	25 APR 96	165	342	320	M	25 APR 92	LCR	334	306
7F7F291538	26 APR 96	165	341	392	M	27 APR 92	LCR	355	338
7F7E42712D	11 MAY 96	119	351	328	M	1 APR 92	LCR	322	286
7F7D222C5A	30 APR 96	137	176	47	U	18 MAY 93	LCR	151	27
7F7D225E4F	27 APR 96	137	277	176	F	28 JUL 91	LCR	190	65
7F7D30290D	19 APR 96	540	273	208	M	20 MAY 92	LCR	160	26

Table 10 (cont'd).

PIT Tag Number	Recapture					Mark			
	Date	Capture Location	Total Length	Weight	Sex	Date	Capture Location	Total Length	Weight
7F7D180674	1 MAY 96	200	288		U	9 JUN 92	LCR	177	39
1F466D2608	6 MAY 96	200	285		U				
7F7D226454	27 APR 96	1110	286	239	F	24 JUL 91	LCR	198	70
7F7F336379	14 MAY 96	137	291	178	M	12 FEB 93	LCR	230	102
1F204E7F74	14 MAY 96	137	292	181	M	10 AUG 93	LCR	252	116
7F7F1F6E3C	17 MAY 96	200	297	236	F				
	2 MAY 96	165	305	242	U	16 JUN 92	LCR	249	104
7F7F291337	13 MAY 96	119	318	276	F	28 APR 92	LCR	293	216
7F7D222632	25 MAY 96	119	314	246	M	28 MAY 91	LCR	224	95
7F7F183807	24 APR 96	1070	401	561	F	28 APR 92	LCR	387	446
7F7E21264E	4 MAY 96	200	394		U	8 MAY 92	61.3*	376	478

\* Colorado River Mile

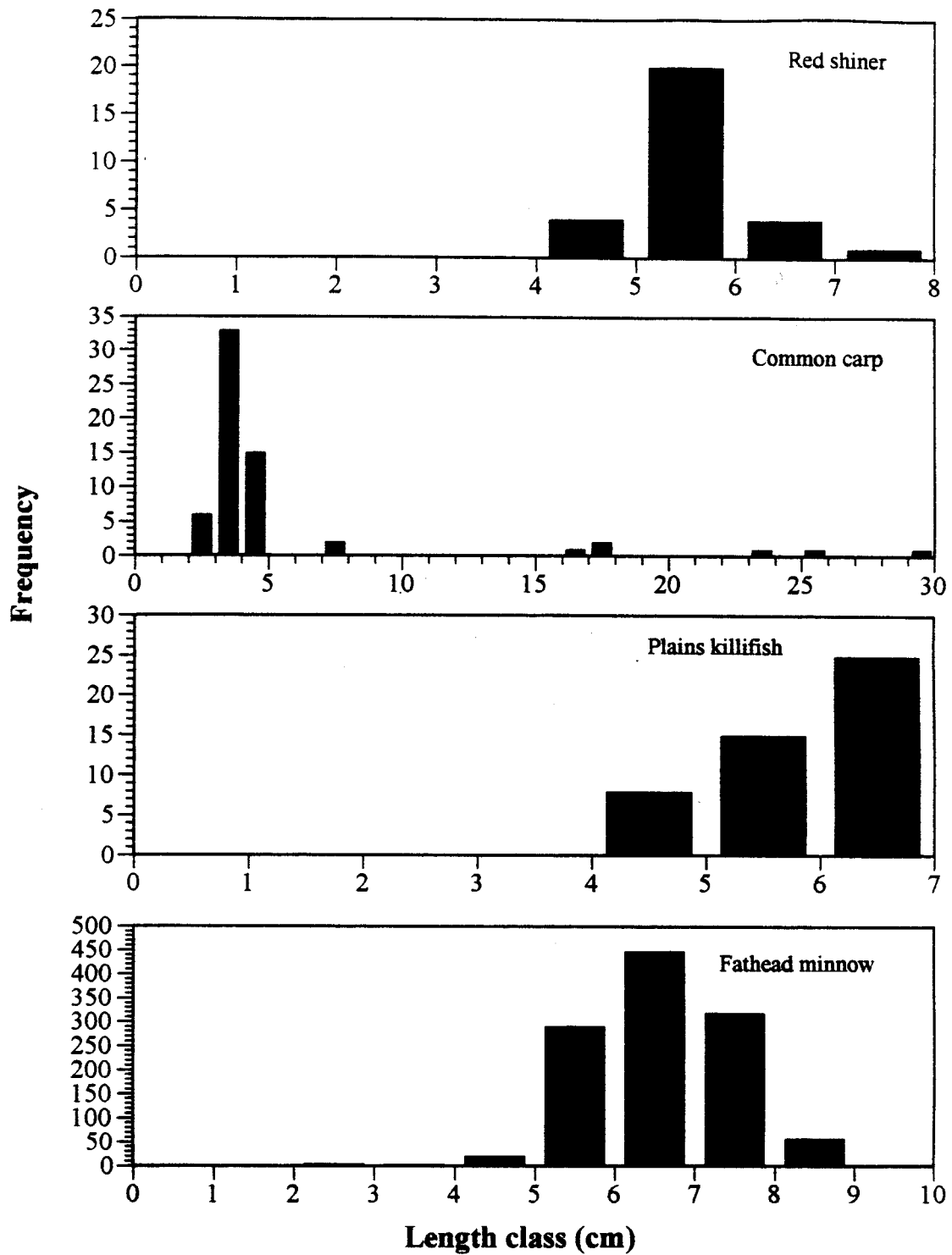


Figure 4. Length frequency of the four most common exotic species caught in the Little Colorado River during spring monitoring, 1996.



## LITERATURE CITED

- Arizona Game and Fish Department. 1996. Ecology of Grand Canyon backwaters. Prepared for the U.S. Bureau of Reclamation, Upper Colorado Region, Glen Canyon Environmental Studies, Flagstaff, AZ. Cooperative Agreement No. 9-FC-40-07940. Arizona Game and Fish Department, Phoenix.
- Brouder, M.J. and T.L. Hoffnagle. 1997. Paria River native fish monitoring 1996 annual report. Final report submitted to U.S. Bureau of Reclamation, Upper Colorado Region, Glen Canyon Environmental Studies, Flagstaff, AZ. Arizona Game and Fish Department, Flagstaff.
- Douglas, M.E. and P.C. Marsh. 1996. Population estimates/population movements of *Gila cypha*, an endangered cyprinid fish in the Grand Canyon region of Arizona. *Copeia* 1996:15-28.
- Dunsmoor, L. 1993. Laboratory studies of fathead minnow predation on catostomid larvae. Klamath Tribes Report KT-93-01. Natural Resources Department, The Klamath Tribes, Chiloquin, OR.
- Gorman, O.T. 1994. Habitat use by humpback chub, *Gila cypha*, in the Little Colorado River and other tributaries of the Colorado River. Prepared for the Bureau of Reclamation, Glen Canyon Environmental Studies, Flagstaff, AZ. U.S. Fish and Wildlife Service, Flagstaff, AZ.
- Hoffnagle, T.L., M.J. Brouder and D.W. Speas. 1998. Mainstem Colorado River fish monitoring, 1996 annual report. Submitted to Grand Canyon Monitoring and Research Center, U.S. Department of the Interior, Flagstaff, AZ. Arizona Game and Fish Department, Phoenix.
- John, K.R. 1963. The effect of torrential rains on the reproductive cycle of *Rhinichthys osculus* in the Chiricahua Mountains, Arizona. *Copeia*:286-291.
- Kaeding, L.R. and M.A. Zimmerman. 1983. Life history and ecology of the humpback chub in the Little Colorado and Colorado rivers of the Grand Canyon. *Transactions of the American Fisheries Society* 112:577-594.
- Kubly, D.M. 1990. The endangered humpback chub, *Gila cypha*, in Arizona - a review of past studies and suggestions for future research. Draft report submitted to U.S. Bureau of Reclamation, Upper Colorado Region, Salt Lake City, UT. Arizona Game and Fish Department, Phoenix.
- Marsh, P.C. and M.E. Douglas. 1997. Predation by introduced fishes on endangered humpback chub and other native species in the Little Colorado River, Arizona. *Transactions of the American Fisheries Society* 126:343-346.

- Mattes, W.P. 1993. An evaluation of habitat conditions and species composition above, in and below the Atomizer Falls complex of the Little Colorado River. Master's thesis. University of Arizona, Tucson.
- Meretsky, V., R.A. Valdez, M.J. Brouder, M.E. Douglas, O.T. Gorman and P.C. Marsh. *in review*. Temporal and spatial variability in length-weight relations of adult humpback chub. Transactions of the American Fisheries Society.
- Minckley, C.O. and H.E. Klaassen. 1969. Life history of the plains killifish, *Fundulus kausae* (Garman), in the Smoky Hill River, Kansas. Transactions of the American Fisheries Society 98:460-465.
- Minckley, C.O. 1988. Final report on research conducted on the Little Colorado River population of the humpback chub, during May 1987, 1988. Final report to Arizona Game and Fish Department, Phoenix.
- Minckley, C.O. 1989. Final report on research conducted on the Little Colorado River population of the humpback chub, during May 1989. Final report to Arizona Game and Fish Department, Phoenix.
- Minckley, C.O. 1992. Observed growth and movement in individuals of the Little Colorado River population of the humpback chub, *Gila cypha*. Proceedings of the Desert Fishes Council 22:35-36.
- Minckley, W.L. 1973. Fishes of Arizona. Arizona Game and Fish Department, Phoenix.
- Minckley, W.L. 1991. Native fishes of the Grand Canyon region: an obituary? Pages 124 - 177 *in* Colorado River ecology and dam management. National Academy of Sciences, editors. National Academy Press, Washington, D.C.
- Robinson, A.T. and R.W. Clarkson. 1992. Annual spring monitoring of humpback chub, *Gila cypha*, populations in the Little Colorado River, Grand Canyon, Arizona, 1987-1992. Final report submitted to U.S. Fish and Wildlife Service, Endangered Species Office, Albuquerque, NM. Arizona Game and Fish Department, Phoenix.
- Robinson, A.T., R.W. Clarkson and R.E. Forrest. 1996. Spatio-temporal distribution, habitat use and drift of early life stages of native fishes in the Little Colorado River, Grand Canyon, Arizona 1991-1994. Submitted to Bureau of Reclamation, Glen Canyon Environmental Studies, Flagstaff, AZ. Arizona Game and Fish Department, Phoenix.
- Robinson, A.T., D.M. Kubly, R.W. Clarkson, and E.D. Creef. 1996. Factors limiting the distribution of native fishes in the Little Colorado River, Grand Canyon, Arizona. The Southwestern Naturalist 41:378-387.
- Rappert, J.B., R.T. Muth and T.P. Nesler. 1993. Predation of fish larvae by adult red shiner. Yampa and Green rivers, Colorado. The Southwestern Naturalist 38:397-399.

Sigler, W.F. and J.W. Sigler. 1996. Fishes of Utah. University of Utah Press, Salt Lake City.

Thieme, M.L. 1997. Movement and recruitment of flannelmouth suckers in the Paria and Colorado Rivers. Master's thesis. University of Arizona, Tucson.

Valdez, R.A. and R.J. Ryel. 1995. Life history and ecology of the humpback chub, *Gila cypha*, in the Colorado River, Grand Canyon, Arizona. Final report to Bureau of Reclamation, Salt Lake City, UT. Contract No. 0-CS-40-09110. BIO/WEST Report No. TR-250-08.

Weiss, S.J. 1993. Spawning, movement and population structure of flannelmouth sucker in the Paria River. Master's thesis. University of Arizona, Tucson.